

The FAA Replaces an Aging Government and Commercial Air Traffic Control System

Pamela Bowers
CROSSTALK

The Standard Terminal Automation Replacement System (STARS) represents a dramatic change in performance of a Federal Aviation Administration system. STARS is a state-of-the-art air traffic control system that will ease the burden on air traffic controllers making the system easier to use and more convenient. It will save a tremendous amount on logistics and support costs, and being digital, additional interfaces can be added as needed.

The Standard Terminal Automation Replacement System (STARS) is a state-of-the-art air traffic control system that provides approach and departure control for commercial, military, and private aircraft. It replaces aging Federal Aviation Administration (FAA) and Department of Defense (DoD) systems across the country. STARS provides increased arrival and departure efficiency and incorporates safety features, including quadruple redundancy and automatic emergency back up.

The delivered product consists of a site-dependent number of terminal control workstations used to control air traffic, and to monitor and control workstations. These are used to monitor and configure the system, perform maintenance, etc. Although the STARS system is "standard," it is entirely parameter-adaptable to accommodate site and operational differences (i.e., runways, radars, etc).

STARS is a safety-critical system that will affect the daily lives of millions of people flying in and out of 331 FAA and DoD sites. The success of STARS will make traveling the nation's airways safer and more convenient. This is due in part to an innovative design decision to minimize air traffic controllers' training, familiarization, and certification by retaining the look and feel of the previous air traffic control system. STARS development provided for the air traffic controllers and Air Force system specialists to be involved from the start in an extensive series of product and development assessment demonstrations, early user involvement events, and a variety of Software Trouble Report/Program Trouble Report (STR/PTR) and Computer Human Interface (CHI) working groups. This involvement was necessary to expose the air traffic control community to the system's features and to incorporate their feedback into all new development iterations.

COTS Was First Choice

STARS is based on open-system architecture using commercial off-the-shelf

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(COTS) technology that provides future extensibility. To reduce complexity of support sites a single, uniform hardware and software architecture was used. This minimizes life-cycle costs for training, maintenance, and sparing. Development, site, and support facility processors use Sun Microsystems with Sun Solaris operating systems using the C language in a Unix development environment with ClearCase configuration management.

To improve display-processing speed associated with commercial display drivers, upgraded TechSource boards were installed in both the Emergency Service Level (ESL) and Full Service Level (FSL) processors. This allows both systems to run concurrently, updating their internal

displays. A software switch allows either of the displays to be quickly brought up on the monitor, improving refresh time for quick cut-overs.

The STARS development contractor, Raytheon's Command, Control, and Information Systems in Marlborough, Mass., is a Software Engineering Institute Capability Maturity Model® (CMM®) Level 3 organization. Raytheon's design employs two commercially available products: AutoTrac-Full Service and TracView-Emergency Service. Using separate non-developmental item (NDI) software for full and emergency service was Raytheon's solution to isolation of problems between the operational system and the backup system.

Raytheon based their source-line-of-code (SLOC) estimates on its historic product metrics database. Government support personnel independently estimated SLOC by decomposing requirements to a module level, then estimating the SLOC per module. Government estimates were validated by function point analysis, and both estimates were reconciled. Since that time, the actual SLOC developed and delivered for STARS has remained within 5 percent of the SLOC estimates.

As customer familiarization with the system progressed through much human interface prototyping, it was decided for safety reasons that the STARS software should be changed to have the look and feel of the current system. (Human factor studies show that under stress or fatigue controllers can revert to old learned habits, leading to mistakes.) Although this drastically reduced retraining and increased safety, it more than doubled the software development effort and required new SLOC estimates for succeeding phases.

The Government's independent cost estimate was developed using three software models (COCOMO II, SLIM, and SEER-SEM). Each model was fine tuned with Raytheon's historic data to reflect realistic productivity numbers and, where

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possible, the model was further adjusted to reflect new development to pre-existent code. The results of the three models were evaluated and compared to produce the most realistic schedules. STARS development has tracked closely to those schedules. Most STARS schedule slippage occurred in post-development, especially in Operational Test and Evaluation.

Quality Makes the Difference

What makes STARS different is the project's extraordinary commitment to achieving quality and customer satisfaction. Air traffic controllers have high pressure, high stress, and safety critical jobs that demand a system that always operates as expected. STARS has the same functionality as the existing systems. In addition it has higher performance, better reliability, more redundancy, and the capability to grow and be enhanced.

Capers Jones, a Top 5 judge said, "This project is important to both military and civilian air travel. It represented careful development practices and much better than average quality control."

STARS developed innovative ways to involve the air traffic controllers and Airways Facility system specialists on a rotating basis from the start in an extensive series of product and development assessment demonstrations, early user involvement events, and a variety of STR/PTR and CHI working groups. This involvement was necessary to expose the air traffic control community to the features of the system and to incorporate their feedback into each new development iteration.

"Thin Specs" were developed to capture CHI requirements at a level of detail significantly below the usual System/Subsystem Specification (SSS) level. Functional verification testing of the system was instituted in parallel with formal system acceptance tests in order to find and fix potential operational problems early. STARS was the first FAA program to implement new security requirements. It has become a model for other FAA projects for its innovative solutions.

Overall the results were impressive. "STARS is literally an application with life and death implications," says Jones. "Therefore extraordinary quality control was essential. The STARS project went beyond conventional quality steps and included some innovative methods for improving human factors and making the system easier to learn and use by air traffic controllers."

STARS ensures product, project, and process quality through application of recognized engineering practices, including



Top Photo: STARS ATB-231 at Northeast Operational Support Facility (NEOSF), Nashua, N.H. Bottom Left Photo: STARS ATB-230 at Washington, D.C. Bottom Right Photo: STARS ATB-232 at FAA Technical Center, Atlantic City, N.J.

CMM Level 3 for software development, ISO standards 9001/9003, and Six Sigma engineering practices for quality. Raytheon's approved quality system plan integrated the FAA's quality engineering procedure to ensure full compliance.

STARS software is subjected to rigorous inspection and test through all acquisition phases. Quality acceptance standards are also imposed on commercial product vendors. All replacement products and upgrades are thoroughly tested for backward and forward compatibility and interoperability with existing STARS products. A hierarchy of Raytheon and government change control boards performs baseline and requirements maintenance.

Measurement, including the cost performance index (CPI) and the project schedule performance index (SPI), are presented routinely at monthly program management reviews. Currently the CPI is 1.03 and the SPI is 0.98, which reflects the program is running within 3 percent of plan. Raytheon uses an earned value management system that fully integrates schedule, performance, and cost data. This data is made available at the end of each month to all personnel. The master integrated program schedule (MIPS) is also integrated into this process.

Within the STARS program, defects receive high visibility and tracking through a number of rigorously monitored means, including monthly program management reviews, biweekly presentations to the project manager, and weekly PTR working group meetings (PTRWG). The purpose of the PTRWG is to classify PTRs, assess PTR symptoms, review proposed resolu-

tions to anomalies, and review analysis of root cause. Raytheon conducts root cause analysis of designated PTRs and provides recommendations for corrections to root causes. The government and Raytheon keep duplicate PTR databases with running totals of the number of PTRs, the time the PTR has been open, and SLOC per PTR closure. This data is used for statistical evaluation.

Success on All Fronts

STARS is the first large procurement program under the Reformed Acquisition Management system. STARS accomplished the total acquisition process in half the normal time.

"Innovations in development included aggressive use of cost, schedule and performance metrics, and the involvement of air traffic controllers throughout development," says Jack Ferguson, a Top 5 judge.

STARS has received very positive feedback and has encountered an unusually low number of problems from its three operational sites: Eglin AFB, Fla.; El Paso, Texas; and Syracuse, N.Y. Both the military and FAA air traffic control communities are eagerly awaiting implementation of full STARS at the remaining sites. To demonstrate the usability of STARS, the FAA and Raytheon have equipped a demonstration van that tours with a working version of full-service STARS.

Due to the success of the acquisition process and the team's outstanding effort, they were awarded the FAA's Office of Research and Acquisition's Sixth Annual Award for "Efficiency of the National Air Space." ♦

The Ogden Air Logistics Center Develops Software That Automates the Minuteman III Messaging System

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CROSSTALK

Without the Higher Authority Communications/Rapid Message Processing Element (HAC/RMPE) developed by Detachment 1, Ogden Air Logistics Center (ALC), the Minuteman III missile crews would be forced to resort to manual message decoding and processing. Instead, Detachment 1's software automatically collects communications data and displays it on computer screens, including duplicate suppression, error correction, and message formatting. The software reduces errors in incoming message formatting and speeds up processing.

The software program maintained by Detachment 1, Ogden Air Logistics Center (ALC) to support the Higher Authority Communications/Rapid Message Processing Element (HAC/RMPE) automatically codes and passes information for the Minuteman III missile crews into a Weapons System Control Element, which has the computer system that fires the missiles. Detachment 1 of the Ogden Air Logistics Center codes the software based on requirements from the Joint Chiefs of Staff and the Commander in Chief, U.S. Strategic Command. This allows the Minuteman III missile crews to receive changes that keep the missiles using the same Single Integrated Operational Plan (SIOP) as the manned bombers and Submarine Launched Ballistic Missiles (SLBMs).

Formerly, those change messages had to be manually handled. They were received over various communications systems printed out in the capsules, then processed individually by hand. The HAC/RMPE software collects incoming messages and displays them on the missile crews' computer screens, including conducting duplicate suppression, error correction, and message formatting. The crews are then able to do any alterations necessary and automatically feed the information into a Weapons System Control Element, the computer system that fires the missiles.

The HAC/RMPE software reduces errors in incoming message formatting and speeds up processing. No operational time has been lost due to failure in the system. "It is a project that successfully handles unpredictable volumes of changing requirements," notes Capers Jones, a Top 5 judge. "It received very high usability scores from users and had very good user satisfaction."

Another judge agrees. "This project had a perfect customer rating and appeared to perform flawlessly in all important cus-

tomers respects," says Watts S. Humphrey.

These accomplishments were made despite the fact that the HAC/RMPE oper-

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ational system is very antiquated, and severely limited in available memory for the additional functions. Yet, despite this limited memory, the Detachment 1 engineers and programmers, led by Toni Estes, Programming Team lead, have never had to decline a new requirement based on technical limitations. In fact, just last year they developed new techniques to allow even more HAC/RMPE messages to be utilized.

The Delivered Product

Staff loyalty is the big thing that contributes to the project's success, stresses Capt. David Selnick, detachment commander. "I can't emphasize that enough. It's a high-pressure environment with short deadlines." In fact, he says that some of the

equipment is so old, they are the only ones in the country still using it; mechanical upkeep is time consuming and difficult as no commercial/private sector languages are used in the operations.

Selnick adds that the team does not get predefined requirements documents. They have to figure that out themselves. "We get information on the fly like everyone else in the SIOP community. We determine the effect on the missiles, and what the software has to do to meet it — all within weeks of the deadline."

Despite the many professional drawbacks to working on this project, Selnick credits the "esprit de corps, importance of the mission, and personal dedication to that mission" for job retention. "More than half of our employees have been here since before 1997 — proving that people are not just marking time or counting the days until they can move to a more marketable position."

Estimation efforts are made based on research, design, and coding time alone. Size is not a factor unless the change request being considered would require alteration of an extreme number of files or use an excessive amount of system memory when operational (since the HAC/RMPE system has very little memory on which to draw). In that case, an estimate of memory usage would be made based upon the amount and type of data to be stored.

A Unit Test Procedure Sheet (UTPS) is used to document all steps that will be taken to test the change. It also doubles as a record of the actual test, as each test step is presented in checklist format.

"David Shaw and SrA Joshua Babcock comprise the detachment's software testing team. They use a system Test Procedure Sheet (TPS), which is similar to the UTPS on a system-wide level. They also update the electronic TPS database, which was created to reuse similar test procedures as well as provide a history in case the

entire system ever needed to be re-qualified. The test report includes the completed TPS form, as well as written documentation of everything that occurred during system testing, including any new or pre-existing but undiscovered problems. Diane Moen, configuration manager, then releases the Software Version Description to highlight differences between the last release and the current one.”

Reliability and Quality

While the technical challenge of this project appears to be typical, the reliability and quality parameters dictate otherwise. “The operational issues and highly sensitive nature of the application appear to make this a demanding technical project,” says Humphrey.

Testing is performed on a HAC/RMPE console that is identical to the consoles in the missile capsules, as well as a simulator for a related system called the Weapon System Control Element (WSCE), which is also located in the capsules. Other test equipment includes a message generator that can mimic message traffic from any of the three communications platforms with which HAC/RMPE is designed to communicate, as well as several PCs and two protocol analyzers. Humphrey also gave the ALC high marks in quality assurance. “The Ogden process is comprehensive and the activities described are important. The broad use of measurements is impressive and the organization appears to be following a well defined and stable process.”

First, peer reviews are conducted for every product produced. These are documented, and metrics are kept on number of defects, type, and rework time. Second, the configuration management program ensures that all release products are monitored, tracked, and documented throughout the entire software development process.

TSgt Scott Sorenson, the software quality assurance (SQA) representative, regularly audits the products for compliance; recommends changes or improvements; and keeps work time, requirements stability, and other relevant metrics. The software process improvement team, which meets as often as needed but at least quarterly, addresses issues that will enhance the simplicity and effectiveness of the software process. This team has at least one representative from every employee work area (process management, programmer/engineering, CM, SQA, and testing) to ensure that everyone’s point of view is considered.

Capt Selnick, a Project Management Professional certified by the Project



Photo left to right, front row: Paul Tomaso (General Dynamics), Toni Estes, Cindy Black, Diane Moen, Barbara Ronsick, Capt. David Selnick. Back row: TSgt. Scott Sorenson, Sr.A. Ian Swang, David Shan, Edward Reed, Sr.A. Joshua Babcock, Ron Heacock (General Dynamics). Missing from photo: TSgt. Curtis Anderson and A1C Aaron Theisen.

Management Institute, provides project oversight. Finally, a combined design review is performed with representatives from General Dynamics who are working on a version of the HAC/RMPE system to be used with a new type of survivable radio communications system. This combined review ensures that nothing “slips between the cracks.”

When determining its effort metrics throughout the process, the detachment defines its versions of cost performance index (CPI) and schedule performance index (SPI) in a manner that best suits their needs. When measuring CPI, cost is assessed in terms of man-hours only. This is similar to the traditional definition of SPI. Goal is 1.0. $CPI = 0.79$

The interpretation of this is that the estimate was within acceptable tolerances – due to the high volatility of the team’s work, anything between 0.75 and 1.2 is considered within control. Capt. Selnick explains that the introduction of late requirements and the deletion of existing requirements at the last minute frequently play havoc with this metric. (Detachment 1 must account for actual hours expended on tasks that were not originally planned for, and it must discount hours spent on tasks that the customer decides at the last minute they do not want).

Regarding SPI, the percentage difference between planned and actual completion dates are computed slightly different than the traditional definition of SPI. Detachment 1 assesses the percentage difference between planned and actual in terms of calendar days. It calculates the length of time from project start to the actual milestone date, and divides it by the length of time from project start to esti-

mated milestone date. In order to get a percentage difference, subtract this number from 1, and multiply by 100. This is a much more important measure to Detachment 1 than is CPI, because its end date is non-negotiable. Therefore, it can tolerate more variation in man-hours than it can in actual date slippage. This metric is calculated at three major milestones: delivery of SIOP Software Specification Matrices, delivery of engineering version of software to The Boeing Company, and delivery of final product to the field. The goal is zero or higher. Positive variation (delivering early) is good; negative variation (delivering late) is bad. All of last year’s numbers were either zero or positive (on time or early).

The Cost per Stage is measured in man-hours. The different stages of the process are assessed in terms of their overall contribution to the total cost of the release. This metric does not include higher-level testing, since these dates and workloads are fixed by external agencies, and the team has little control over them. This historic data allows it to improve its estimation process.

What is the result of all these efforts? Operators have never encountered an error that would require them to stop using the software. No mission time has ever been lost due to a HAC/RMPE software error. SIOP interdependence means the software release date cannot be missed. While mandatory requirements are often introduced or changed months after they are supposed to be finalized, Detachment 1 has never failed to meet a date, and, in fact, often releases early. Required software functionality has never been reduced in order to meet the deadline.◆

The F/A-18 Advanced Weapons Lab Successfully Delivers a \$120-Million Software Block Upgrade

Pamela Bowers
CROSSTALK

As the F/A-18 Hornet becomes the Navy's nearly exclusive strike fighter, the Advanced Weapons Laboratory (AWL) steps up to the task of delivering a major software block upgrade. The software, called the 15C System Configuration Set (SCS), provides advancements that upgrade the interface between the aircraft mission systems and the aircrew. The AWL successfully delivered "real time" processing in an extremely mission critical system that pushes the technology envelope, and that requires absolute safety of flight.

The F/A-18 Hornet is the Navy's premier strike fighter, which now forms the core of the Navy's air warfare capability. As older aircraft are phased out of inventory, and the newest variant the F/A-18E/F is phased into the fleet, combat aircraft on the Navy's carrier decks will consist almost exclusively of F/A-18s. It is truly the heart of naval carrier aviation. The F/A-18 also serves as the primary fighter with seven U.S. military allies.

Success in today's air combat arena is a function of many variables. One of the most important is aircraft mission systems and their interface with the aircrew, especially in an era of exponential improvements in digital technology. The F/A-18 Advanced Weapons Laboratory (AWL) delivers these improved warfighting capabilities to the fleet.

As a full life-cycle activity, the F/A-18 AWL provides mission-system-engineering support for F/A-18E/F, as well as life-cycle support for out-of-production F/A-18A/B/C/D aircraft. The AWL coordinates F/A-18 system upgrades and enhancements and provides systems engineering for F/A-18 hardware and software. It accomplishes every aspect of the life cycle of the system configuration sets (SCS), including the software design for the mission computers and the stores management system. For the E/F aircraft, the AWL acts as system engineers and performs test activity; their teammate The Boeing Corporation is the design agent. Additionally the AWL manages a wide range of avionics and weapon systems developments, weapons integration, and foreign military products.

The F/A-18 AWL develops its own simulation laboratories, test equipment, and flight instrumentation; it generates and manages aircraft modification proposals and flight clearances. In its six integration and simulation laboratories, the AWL per-

forms detailed subsystem and integration tests. The F/A-18 AWL and their Boeing teammates are Software Engineering

"This is a very large, real-time operational system that has made significant improvement in cost, schedule, and quality."

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Top 5 Judge

Institute Capability Maturity Model® (CMM®) Level 4 software facilities. The AWL is well on its way to Level 5.

"The developers' transition to CMM Level 4 has resulted in reduced rework and reduced costs of test points," says Gary Kessler, Naval Air System Command representative. "The fleet is ecstatic."

Functioning as part of a greater F/A-18 Integrated Product Team (IPT), the people of the F/A-18 AWL are a Navy/industry team whose major contractors are The Boeing Corporation, Raytheon, and many other prime and support contractors. From technical leadership to business and financial management, they provide progressive, experienced

management expertise for all levels of programs across a wide variety of disciplines.

Scope of the Project

During the top five contest award period of January 2000 to June 2001, the AWL delivered to the operational testers (VX-9) a major software block upgrade called the 15C SCS. This was approximately a \$120-million effort that incorporated more than one hundred requirements. Here are just a few of the major products implemented in the SCS: the Joint StandOff Weapon, the AIM-9X Sidewinder, the Joint Helmet Mounted Cueing System, the Multifunctional Information Distribution System, the Digital Communication System, and the requirements from six foreign military sales customers.

"The 15C SCS effort was long and complex," says Boeing Block Captain Doug Garrette. The project began in the first quarter of 1997. The initial plan consisted of three builds with 61 USN statements of requirements (SORs) and 14 Foreign Military Sales SORs, he says. It grew to four builds and picked up 59 impact statements (additional requirements).

"The SCS involved the integration of three new weapons, five new avionics systems and a new aircraft configuration (A+)," says Garrette. Each of these programs was driven by their own schedules and needs, he adds. "15C had to be flexible and react to the dependencies that were brought on by these parallel activities. It was through the dedicated effort of the combined USN/Boeing team that commitments were met."

Watts S. Humphrey, a Top 5 judge noted the vast scope of the project. "While the technology appears to be relatively standard, at least for the set of best projects, the size, complexity, and number of systems involved does represent a significant technical challenge in itself."

In addition, the team was not co-located

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ed but came from different organizations, says Barry Douglas, Advanced Weapons Laboratory, IPT lead. "But that didn't matter," he says. "The team pulled together from the beginning, overcame development difficulties posed by their separation, and produced a successful product."

The aircraft has more than 10 million words of code in more than 40 different processors. Each aircraft type has two distinct configurations. The major differences include the stores management computer (Q-9 or AYK-22), multiplex bus architectures (either five or six), radars (APG-65 or APG-73), two variants of the AYK-14 mission computer, and various other minor differences. The airframes different processors are programmed in eight variants of assembly language, and in Ada, C, PL/M-86, and Jovial. The software development environment also uses Fortran, Ada, and C.

The majority of the effort was in the two mission computers, stores management set, and radar. The software development environment has more than 4 million source lines of code (SLOC) in unique software. The documentation contained the complete set of logistics elements that include the following: aircrew publications, maintenance publications, training, trainer updates, technical directives, and mission planning module software.

Methods to Ensure Quality

The mission computer software team's effort was larger and more complex than most members had ever experienced, notes Kim Brestal, Boeing software lead. "The task included implementation of an extraordinary number of requirements representing new weapons, new aircraft systems and a new aircraft configuration."

"The biggest challenge, by far, was providing for efficient use of critical mission computer resources to allow for successful implementation of all the requirements," says Brestal. "An MC resource team was formed to devise and implement risk mitigation plans for each affected resource."

Truly this project was large and complex agrees Capers Jones, a Top 5 judge. "The combination of low rates of delivered defects and high levels of customer satisfaction indicates this project was very well planned and managed." Jones cites the AWL's processes as a key to their success. "The project was produced by a SEI CMM Level 4 organization, and demonstrates the value of the higher CMM levels."

To achieve this quality goal, the AWL team performed the following:

- Achieved a CMM Level 4 and aggressively

sively started moving to Level 5.

- Used the Capability Maturity Model®-IntegratedSM to assess organizational maturity and process area capability. Established priorities for improvement and methods to implement these improvements.
- Published, updated, and distributed a strategic plan that defines basic core beliefs, visions, and mission.
- Tested jointly with the Operational T&E Squadron throughout the verification phase of 15C. This gave them an early look at the product and gave the AWL earlier insight into operational problems in the product.
- Published an F/A-18 AWL Management and Systems Engineering Process Manual to systematically identify and apply leverage to areas of weakness and expand on what they do right.
- Maintained and improved its system-configuration review board process to obtain a very solid, well thought out, and adequately funded set of requirements.
- Improved on and used a comprehensive set of metrics. An example of the numerous metrics used is the indicator used to indicate software maturity level. At 0.12 software anomaly reports per test hour, the software is ready for operational test.

Results Show Success

The group not only produced the 15C SCS, but also was developing additional major SCSs, each at different stages, all at the same time, says Douglas. During the past 10 years, the AWL delivered four major F/A-18C/D SCSs as the total aircraft software increased to more than 10 million words. Each showed constant and unprecedented improvement. Considering 15C as the latest SCS, the following data apply:

- Reduced cycle time from 56 months to 38 months.
- Reduced schedule slips from 12 months to on time.
- Decreased rework rate from 20:1 to 3:1.
- Decreased regression testing from 70 percent to 20 percent.
- Decreased redundant testing from 100 percent to 10 percent.
- Improved test efficiency from 0.42 to 1.6 test points closed per hour of test time.

SCS 15C had the following specific indicators:

- Defect density was very low, 3.8 defects per KSLOC – down from 13.5.
- Productivity in the design phase was



Top Photo: A VX-9 F/A-18 Aircraft Over the China Lake, Calif., range. Bottom Photo: The F/A-18 Advanced Weapons Lab located at China Lake, Calif.

3.45 man-hours per SLOC – down from 15.7.

- Design phase cost was \$200 per SLOC – down from \$725.
- Life-cycle cost was \$400 per SLOC – down from \$1,170.
- The number of test flights was 0.6 flights per KSLOC – down from 3.1.

To date, the fleet has not reported any problems with SCS 15C. Likewise, the AWL has yet to receive any software trouble reports from the fleet on its similar product, System Configuration Set 13C, delivered three years ago.

"This is a very large, real-time operational system that has made significant improvement in cost, schedule, and quality," says Jack Ferguson, a Top 5 judge.

Accomplishments Are Applauded

For software of this size and complexity, the AWL feels this is one of the top software projects in the government for total life-cycle costs, quality, schedule, and performance. It says this is especially commendable considering this is "real time" processing in an extremely mission critical system that pushes the technology envelope, and that requires absolute safety of flight.

If the high cost of flight test vs. the commercial process of free "beta testing" is factored out, this software is a bargain in any commercial market, says Douglas. "The overall cost and quality statistics for this level of effort are truly outstanding, but the improvement during the past 10 years is truly phenomenal." ♦

The Bureau of the Census Delivers the First System to Use Digital Imaging Technologies to Process Forms

Pamela Bowers
CROSSTALK

For the first time ever, the Bureau of the Census (BOC) used imaging and recognition technologies to process forms resulting in more data being received faster than ever before. The BOC and Lockheed Martin successfully developed a system that automatically processed more than 150 million multi-page Census forms in 170 days. In the end their data accuracy was exceptional, reaching 99 percent.

The Bureau of the Census (BOC) contracted with Lockheed Martin Mission Systems to deliver an imaging and recognition system that would automatically process more than 150 million multi-page Census forms in 170 days. The delivered product was the DCS2000 system; a fully integrated system capable of logging and electronically reading census forms, storing the data on high fidelity backup tapes, and tracking the data via large, Oracle-based databases.

The DCS2000 program was an extremely high profile event with milestones and deliveries set by Congress. To miss these would subject the program, and the BOC, to a high level of scrutiny from Congress and the General Accounting Office, as well as the press. DCS2000 met all major milestones, delivering a high quality system exceeding all accuracy requirements. Notably, it was the largest, most accurate imaging and recognition program in history. The DCS2000 was the first Census using digital imaging, and the first handled by contractors.

The resulting system was deployed to four Data Capture Centers across the United States and began processing Census forms on March 6, 2000. Each Data Capture Center is staffed by approximately 2,000 people who collectively processed the equivalent of 1.5 billion pages of information in just 170 days – the largest data capture ever. The integrated system is capable of the following:

- Quickly checking in large numbers of U.S. Census forms.
- Electronically reading the data on the forms (known as Title 13 data).
- Storing the data in large, flat files that were shipped nightly to the BOC customer.
- Tracking the data and the forms movement through the system via large, Oracle-based databases.
- Providing a keying function for error correction.
- Backing up data to tape.

- Ensuring that forms could be shredded at the conclusion of the processing (with confidence that no data was lost). The system was developed using a

"A solid methodology of communications was adopted to ensure that problems were addressed at the appropriate levels."

– Brenda Zetervall
Top 5 Judge

"cluster concept" that allowed for proper system scaling (depending on BOC needs). A cluster included three high-speed scanners and all peripherals needed to support those scanners. In total, 33 vendors were brought into the solution and integrated into the DCS2000 system.

"This project was technically challenging and completed quickly," says Capers Jones, a Top 5 judge. "It made use of new technologies and also was required to process an extraordinary volume of data when deployed."

Development and Use Environment

The DCS2000 System was developed at

the Bowie Computer Center in Bowie, Md. (a customer location that houses the BOC computer facilities). The program used a spiral development model and developed the custom code in C++ on a Windows NT platform. The two major databases (status and management) were developed using Oracle.

The architecture used on the DCS2000 program allowed for a multitude of changes to occur without changing the fundamental design. It was expandable, so as requirements increased, the system was able to get larger without a redesign.

Adherence to a well-defined software development process was a must for an effort of this magnitude. Lockheed Martin Mission Systems was recently certified Software Engineering Institute's Capability Maturity Model® Level 5 for software development, in part based on the independent assessment of DCS2000 processes and procedures.

A multi-functional lab installed in the Bowie Computer center with the following environments: development, software integration and test (SWIT), and system test. A configuration management department ensured that the baselines for each environment was up to date.

"A solid methodology of communications was adopted to ensure that problems were addressed at the appropriate levels," says Brenda Zetervall, a Top 5 judge. She noted that the BOC technical staff became members of the Integrated Product Teams during the development and test period. As such, the BOC had detailed insight into the direction that each technical product was taking and was able to influence key technical decisions. At the management level, daily meetings were held between the DCS2000 Program Manager and the BOC counterpart. Regularly scheduled executive meetings were also conducted at the director and vice president level with their BOC counterparts. In addition, Zetervall says that the program had a robust metrics

process that identified problems early (before they became large and unwieldy).

"The biggest contributor to the project's success was the complete openness between the BOC customer and ourselves," says Bill MacDonald, program manager, DCS2000. "There was nothing kept back. If we had a problem, the customer was part of the integrated development team that met daily."

In fact, three separate stand-up meetings were held daily, says MacDonald. There was a morning program management meeting, next came a midday teleconference, followed by an evening roundup meeting, explains MacDonald. "We functioned as a cohesive team," he says. "They had complete confidence we were telling them everything."

The final system was installed at four data capture centers located in Baltimore; Jeffersonville, Ind.; Phoenix, Ariz.; and Pomona, Calif. Each data capture center had a high-speed link connecting it to the central technical support function at the Bowie Computer Center.

Changes Made, Quality Maintained

The DCS2000 program went through a number of requirements changes prior to delivery. Twenty-nine contract modifications totaling \$170 million were negotiated during the development and support of the program. On many occasions the change requests were the result of congressional action. For instance, the BOC had originally planned to use a statistical sampling technique for distribution of forms. That decision was reversed and therefore a change request was submitted to accommodate a traditional census.

Some change requests were made to mitigate risks jointly identified by Lockheed Martin and the BOC. For instance, a risk to the timely completion of data capture was identified whereby, if the production keyers did not reach a certain keying rate, data would not be available to report to the president of the United States by Dec. 31, 2000. To mitigate that risk, a major engineering change proposal was drafted, approved, and implemented four months prior to the beginning of data capture. This change allowed the system to process the data necessary for delivery to the president (called 100 percent data) and allowed a second pass to capture all other data.

There are two reasons for keyers being part of the system. First, not all marks and characters could be read with 100 percent accuracy. When a field did not fall within a



Photo: The Lockheed Martin "Nova" team award recipients for outstanding contributions on the U.S. Census Program.

predefined confidence level, it was sent to a keyer for validation. For instance, if the word was "Smith" and the system was unsure whether it was "Snith" or "Smith," a keyer would look at the field (electronically) and make the necessary entry. This was known as Key From Image. In addition, for those forms that were mangled, the system had a Key From Paper capability. This allowed direct entry into the system manually.

The second reason for keyers was for quality control. Constant sampling was done whereby the data from a completed form was pulled, the form sent to a keyer, and then routed to another keyer. The data was then compared to the original electronic processing. If all three matched, then the electronic processing was successful. This was all done without keyers knowledge, i.e., the keyer did not know whether they were processing a field that was low confidence, or processing a field for quality control. This allowed the BOC to assess the system accuracy.

All engineering change proposals (ECPs) were completed on or ahead of schedule. Metrics for the DCS2000 program were collected and presented to program management and the customer on a monthly basis. A Schedule Performance Index (SPI) of 1.07 and a Cost Performance Index (CPI) of 1.0 showed a program that was ahead of schedule and on budget. Other metrics collected and presented showed a steadily improved defect rate for development, Software Integration and Test (SWIT), and systems integration (SI) test.

A robust, automated quality assurance (QA) process that measured the quality of

the imaging and recognition system was built into the DCS2000 system. This process allowed for continuous monitoring of system performance/accuracy and allowed the DCS2000 team to do additional tuning for greater accuracy. In fact, the accuracy of the data sent to the BOC exceeded all expectations. Specifically, results independently measured by Rochester Institute of Technology indicated 99.89 percent data accuracy for optical mark recognition and 99.4 percent data accuracy for optical character recognition.

This program was a highly visible development effort with a congressionally mandated schedule that could not slip. An open style of communication was established with each vendor, which led to a true teaming concept. Each company understood their part and considered the success of the Census paramount to decision making (as opposed to what was best for an individual company). This attitude strengthened the final product and made it a truly integrated system.

"This project team arranged a great partnership and reacted well to customer direction," says Alan Berlinger, BOC Data Capture program manager. "They started with a firm deadline, but ambitious requirements. They ended with ... the largest data capture effort ever."

"Never before has the BOC processed so much data so quickly," says MacDonald. "When you consider the magnitude of this program, the congressionally mandated milestones, and the large number of changes to the baseline, it is easy to see why nothing short of a true partnership between government and private sector could make this work." ♦

The TRW Tactical Systems Division Builds the Next Generation of Tactical Army Operations Systems

Pamela Bowers
CROSSTALK

Revolutionary changes in warfare are possible with the Force XXI Battle Command – Brigade and Below (FBCB2) project built by TRW. It is a system of networked computers, radios, and communications systems that provides soldiers in the field with situational information that allows them to be as effective as possible in conducting their mission. Users operating the system know what to do, where to go, what surrounds them, how to avoid danger, and more.

The Force XXI Battle Command – Brigade and Below (FBCB2) project provides breakthroughs in the effectiveness of the tactical Army. The system is an over-the-air network of computers, radios, and communications systems that enables the Army to utilize knowledge for combat advantage. FBCB2 is designed for intense, dangerous, conditions with life-or-death consequences for Army forces.

The primary users are soldiers ranking from private to colonel, possibly higher – primarily operating their FBCB2 systems within vehicles. They interact with the system using a touch screen and a graphical user interface designed to be tolerant of strong vibration and temperature. The users also include a class of specialized personnel doing network management and other executive functions situated in tent complexes or special command vehicles known as Tactical Operations Centers (TOCs).

In a typical brigade (or larger) mission, FBCB2 is hosted on hundreds of vehicles (exercises have been run with approximately 1,000 vehicles). Users are in collaborative, near-real-time contact with each other as the system shares location information called situational awareness (SA) data and command and control (C2) messages (e.g., orders, descriptive map overlays, logistics requests, alerts/warnings, and status reports). Users employ the system to know what surrounds them, what to do, where to go, how to avoid danger, etc. Frequently the system is operated “on the move,” including at night or in poor visibility conditions. FBCB2 also includes planning tools to help a commander plan and analyze a mission.

FBCB2 is proclaimed by the Army customer and users as a “home run” in next-generation operations and a revolutionary change in warfare in these ways:

1. Expanding the range of operations.
2. Reducing reliance on already scarce voice communications availability by providing position information digitally

- and automatically.
3. Coordinating maneuver at night, in bad weather, or during times of reduced battlefield visibility.



4. Minimizing the commander’s unknowns in his decision cycle.
5. Reducing fratricide.
6. Increasing the force’s lethality.

Complete Source Code Control

The challenge to FBCB2 software development was to build something over which complete control of the source code was maintained. Since the Army is buying about 60,000 platforms, it did not want to have any significant licensing costs to drive up overall deployment costs.

TRW is the prime FBCB2 contractor and provides project management, engineering, software development, systems integration, and test and life-cycle support.

Raytheon is a major teammate on FBCB2 for almost half the software, especially SA and C2. TRW also oversees the development, test, and fielding of FBCB2 computers, communications hardware, and platform installation.

Software size estimates history for the Version-1 FBCB2 proposal was generated by two parametric cost models: Constructive Cost Model (COCOMO) and Revic. These were calibrated to TRW projects estimating 250 thousand source lines of code (KSLOC). Subsequent FBCB2 versions’ estimates for costing, planning, and tracking purposes were based on a more modern technique of “required capabilities” (somewhat analogous to function points), not SLOC. The relative proportions of the present Version (v3.4) of FBCB2 are approximately two-thirds developmental, and the balance a mixture of commercial off-the-shelf, government off-the-shelf and non-developmental items.

The Contract Data Requirements List (CDRL) requirements are comprehensive, even though FBCB2 is an evolutionarily developed and incrementally delivered battlefield system. Twenty eight document types ranging from the Software Development Plan (SDP) and Software Product Specification (SPS), requirements documents, Interface Control Documents (ICDs), and architecture (and other) trade studies to software test, quality plans, and user training materials have constituted more than 900 version deliverables and approximately 110,000 pages. All deliveries are now in electronic form.

The FBCB2 software development environment matches the customer’s principal target platform – Intel computers running Posix-compliant Unix (Solaris) – for the advantages of more realistic early testing and reduced risk by avoiding cross-compiling and building. As cost savings, developers have Windows PCs on their desktops (running Microsoft Office for office productivity functions), with network log in to the Unix machines, which comprise the compi-

lation and test environment.

Compilers are freeware Gnu compilers. The X-Designer tool is used for screen designs and rapid, reliable template code generation. RTM is used for requirements management and test traceability. FBCB2 employs an integrated configuration management and software problem report process, and has recently migrated its tools support to Rational ClearCase/ClearQuest from earlier tools because of more efficient support for multiple baselines, with the added benefit of metrics collection and analysis.

Three operational usage environments (operating system/hardware configurations) cover the 40-plus types of Army vehicles and aviation platforms upon which FBCB2 is installed: Intel machines running Solaris, Sun SPARC machines running Solaris, and Intel machines running LynxOS. The first Intel/Solaris environment was selected for cost effectiveness, given more than 9,000 initial FBCB2 installations. The other two are the environments in existing systems into which core FBCB2 functionality is being embedded.

Customer Satisfaction Equals Quality

More than 60 FBCB2 software deliveries have been provided to exercises, training commitments, and demonstrations providing the ultimate proof of quality: high user satisfaction with no major problem reports. Instead, FBCB2 receives increasing demand for capability expansion beyond contract scope.

User evaluation and feedback at every stage of product evolution is a primary FBCB2 quality method. FBCB2 also employs quality processes and procedures that ensure delivery of verified products within predictable cost and schedule. These processes are based on TRW's quality systems that exceed ISO 9001:2000 and the Software Engineering Institute's Capability Maturity Model®.

Management proactively monitors the project and conducts risk management using metrics-driven decision making. Monthly cost/schedule-variance reviews focus on individual task achievements vs. planned schedule and cost budgets to assure contract programmatic satisfaction. Monthly metrics reviews emphasize quality factors such as defect density, key system performance parameters, schedule satisfaction of derived task-level activities, tracking of critical-activity paths, staff leveling, and measuring compliance with project/contract plans.

FBCB2 has introduced advanced statistical process control methods to better identi-



Image: FBCB2 can be used in a vehicles to gain information superiority and a tactical advantage.

fy problem areas and exemplary sub-processes for process improvement. A near-daily software Configuration Control Board (CCB) meeting expedites field/test recommended changes; a higher-level project CCB controls baselines in project configuration management and enforces the disciplined boundary between development and formal integration and testing.

Capers Jones, a Top 5 judge commended the project's processes when he said, "This project is large enough to be hazardous, and yet the development team was successful in building it with few residual defects. The size of the project was stated to be about 2,300,000 SLOC or roughly 22,000 function points. Project management and both risk and quality control on this project were extremely proactive."

Good Field Ratings

No major deficiencies have been reported in scheduled product deliveries, i.e., there has been no leakage of significant defects from final, customer-witnessed formal testing to delivered products. Because of consistent, flawless delivery of required functionality, and the revolutionary character

and break-through capabilities of the FBCB2 system, most of the reports received from the field (dozens) are "good ideas" for enhanced functionality beyond contract requirements, not problem reports.

The bottom-line implication is that all substantive problems in contracted software capabilities are detected and fixed by FBCB2's multi-level developmental test processes before fielding.

Many field events attest to FBCB2's revolution in ground warfare. Following is a comment from the project's Division Capstone Exercise: "On 2 April, tanks and other heavy armored equipment were able to ignore a blinding sandstorm and cause the opposing force (OPFOR) to lose 60 percent of its combatants," said Col. John Antal, exercise chief of staff. "You couldn't see your hand in front of your face. On the FBCB2, that's the computer system on the tanks and the Bradleys, the friendly forces knew where they were," he said. "They didn't fire artillery at themselves. They know what the [terrain] obstacles were and they had a good read on the enemy," ... thus defeating a usually invincible OPFOR. ♦

Photo: Part of the Main FBCB2 Team at TRW's Dominguez Hills Technology Center.



CROSSTALK Honors the 2001 Top 5 Quality Software Projects Finalists

Pamela Bowers
CROSSTALK

There were so many successful government projects entered in the first Top 5 Quality Software Projects contest that it was difficult to narrow the field. As a result, the following 11 projects are being honored as 2001 Top 5 Finalists. A brief description of each project is included here. Look for a more detailed article on many of these projects in upcoming CROSSTALK issues.

CWS – Command and Control Mainframe System **Customer:** Air Force Satellite Control Network, Command and Control Segment Sustainment

The Command and Control Sustainment Contract (CCSC) team delivers software fixes that allow the Air Force operational community to command and control satellites at a high success rate. The CCSC team delivered 25 products between January 2000 and June 2001 to ensure the success of 14 unique satellite control complexes of the Air Forces Satellite Control Network. These deliveries included non-scheduled emergency software deliveries as well as scheduled software maintenance deliveries in support of satellite command and control. For this time period, the CCSC team has not introduced any priority problems to the operational baseline for any baseline or emergency products delivered to the operational command and control complexes.

Industrial Automation **Automated Testing Software** **Section/F100 Windows** **Intelligent Trending and** **Diagnostic System**

Customer: Information Resources
Branch of the Propulsion Directorate

The Windows Intelligent Trending and Diagnostic System (WITADS) software analyzes performance data of the F100 engine to predict impending problems, reduce diagnostic time on the flight line, incorporate corporate knowledge into the software, and utilize current field equipment. WITADS analyzes downloaded jet engine in-flight data to determine health, faults and/or alarm cautions associated with the engine, and provides a prediction of future engine faults or cautions.

The field service evaluation (FSE) process was utilized to determine the

operational/objective status of the program. For example, FSE documents reported that ITADS was identifying possible failure modes before failure. This

*"The project descriptions
and results submitted for
this award [Top 5]
provide one of the best
models for building
future projects that I
have seen in many
years."*

– Capers Jones
Top 5 Judge

saved additional damage to the engine by catching the possible failure and preventing damage down stream. For example, the annual cost avoidance for damaged F100 engine afterburner exhaust nozzles is approximately \$1.5 million.

The F100 engine is used in the F-15 and F-16 fighter aircraft, thus two versions of the software are required. WITADS is an artificial intelligence system using a rules-based expert-system methodology derived from the technical knowledge of Air Force (AF) engineers and engine manufacturer specialists. WITADS is designed to interface with the standard ground station software used by flight-line technicians at F-15 and F-16 AF bases worldwide.

Investigative Information **Management System Program** **Management Office**

Customer: Air Force Office of Special
Investigations

The Investigative Information Management System (I2MS) is the only activity-based business workflow and information management system that provides Air Force Office of Special Investigations field agents with the ability to capture all of their investigative data in one place and then generate the final product for the customer. It is a true workflow system that follows the investigator through every aspect of criminal investigations, from murder to espionage and everything in between.

I2MS is a user friendly means of tracking and saving all collected investigated information with reports being automatically populated and published. The I2MS data structure allows for link analysis on the fly, which means an investigator will have all previous reports and incidents related to the suspect at his or her fingertips during subsequent investigations. Also, investigative leads that previously required days of mail-time and hours of briefings with assisting investigators are now conducted completely within the confines of the database. The organization estimates it will recover its costs within three years of operation in addition to the increase in capability and the reduction of missed investigative steps due to human error.

Lockheed Martin Mission **Systems All Source** **Analysis System**

Customer: Project Management
Office Intelligence Fusion

The All Source Analysis System (ASAS) program produces a family of intelligence analysis software products. These products provide intelligence analysts common applications, communications manage-

ment and message processing, and situation awareness/development tools to create an accurate and timely common picture of the battlefield. The system has passed its developmental and operational testing and is, in fact, operational and deployed worldwide and is in the hands of soldiers in the field today. Army intelligence analysts in the Balkans are using the system to provide critical intelligence in support of their ongoing mission. Its true value may only be measurable in terms of mission accomplishment or lives saved in future actions.

The systems have been engineered to support maximum interoperability and flexibility for the intelligence community by providing Battlefield Systems Interfaces, accommodating other Battlefield Functional Area clients and utilizing government off-the-shelf and commercial off-the-shelf software. Twenty-two deliveries occurred in the last 18 months with all 97 contract data requirements lists delivered on or ahead of schedule. The ASAS Block II Remote Workstation software is the intelligence and electronic warfare component of the Army Battle Command System.

Minuteman Automatic Test System for Launch Facility Operational Ground Equipment (MATSO)-OO-ALC/TISMB

Customer: LBM, Intercontinental Ballistic Missile System's Program Office Ground Systems Division

The Minuteman Automatic Test System for Launch Facility Operational Ground Equipment (MATSO) team provides high quality software support for the Minuteman and Peacekeeper Missile defense program under the goals of the Software Capability Maturity Model® (SW-CMM®). The TISMB provides an invaluable service to ensure that an aging defense system is maintained to peak performance. TISMB uses statistical methods such as control limits that have been established for cost and schedule metrics. This metrics indicates whether TISMB is in control of their processes, and where problems are likely to occur. Data is used to initiate process changes as needed. Defect data provides TISMB with the necessary information to perform a causal analysis on the defects found at peer reviews. This causal analysis not only removes the defect, but also prevents the recurrence of the defect in the future.

Using the best information available, indications are that process improvements have reduced maintenance schedule and

costs. Software releases for TISMB have been virtually error-free. TISMB is able to produce a higher quality product at reduced cost. MATSO was a focus project of its parent organization's SW-CMM® Level 5 assessment and for the past several years has consistently rated Level 5 on internal quality assurance reviews.

NASA Glenn Research Center/Numerical Propulsion System Simulation

Customer: NICE-1 Consortium, comprised of NASA Glenn Research Center, General Electric Aircraft Engines, Pratt & Whitney, The Boeing Company, Honeywell, Rolls-Royce, Williams International, Teledyne Ryan Aeronautical, Arnold Engineering Development Center, Wright Patterson Air Force Base

Numerical Propulsion System Simulation (NPSS) V1.0 is an object-oriented preliminary and conceptual design code used by aerospace engineers to predict and analyze the aero-thermodynamic behavior of commercial jet aircraft, military, and rocket engines. NPSS V1.0 also allows the dynamic substitution of its engine components (objects) to components (objects) of greater fidelity; a concept called Numerical Zooming. It is written in C++ and was developed following a production software engineering process. NPSS was developed to reduce cost and risk and increase capability and accuracy by numerically creating aerospace propulsion systems before hardware is ever built. NPSS V1.0 is the first deliverable from this vision.

National Missile Defense Battle Management, Command, Control, and Communications

Customer: National Missile Defense, Joint Program Office, BMC3 Program Office

The National Missile Defense (NMD) system is comprised of weapon, sensor, and Battle Management, Command, Control, and Communication (BMC3) elements that provide the capability to detect, engage, and negate threatening inter-continental ballistic missiles. The BMC3 element provides the integrating mechanism for controlling and directing all aspects of the NMD system operations. TRW is responsible for developing and employing the battle management command and control, test exerciser, in-flight interceptor communications system, and communications node equipment/network system manager (pri-

marily COTS integration). Since 1995, TRW has delivered five BMC3 product increments and successfully achieved all technical milestones for the 30-month NMD basic contract. TRW cost was \$1.9 million under budget with less than 1 percent schedule variance.

Naval Oceanographic Office, Geophysics Fleet Mission Program Library

Customer: Commander, Naval Meteorology and Oceanography Command

The Geophysics Fleet Mission Program Library (GF MPL) is a rapid-response, on-scene, environmental prediction software suite used to quickly assess the effects of the environment on fleet sensors, platforms, and weapons systems. Products include electromagnetic/electro-optic propagation conditions and oceanographic acoustic predictions. The software applications in the library are used to increase safety for the warfighter and to increase his combat effectiveness.

The number of its operational customers and the number of complaints on software problems determine the measure of value for GF MPL. For example, if a customer uses the tides application to plan a ship's entry into a port and the ship arrives safely, then that is an important measure of effectiveness. If a Navy Seal uses the solar lunar application to determine moonrise and lumination factors for mission planning, and the application forecast is accurate, then the value is priceless. In 2001, GF MPL was sent to more than 330 operational customers with no complaints of software defects. The GF MPL release is on a fixed schedule of six months per iteration. Analysis of the last iteration indicated that process efficiency resulted in a 23 percent increase in actual versus planned requirements.

Ogden Air Logistics Center, Radio Solar Telescope Network Re-Host Software

Customer: Space and Missile Systems Center, DMSP/SESS Division, Software Branch SMC Det 11/CIDS

The Radio Solar Telescope Network (RSTN) re-host project will replace the computerized portion of the Radio Interference Measuring Sets (RIMS). RIMS is part of the RSTN and consists of eight radio frequency meters that measure solar emissions. The RSTN re-host system is a functional replacement for the HP-1000 computer system currently in use at

four of the U.S. Air Force Radio Solar Observatories.

The HP-1000 uses Fortran and assembly language software routines to analyze and display radiometer activity to the user and compose solar weather messages to transmit to a central facility. By eliminating the older hardware and software, this project will save an estimated \$160,000 per year paying for itself in the first year or two. In addition, this project will eliminate a number of maintenance problems and associated costs. Installation started a full month earlier than expected.

Other benefits include reduced training due to the re-hosts' graphical user interfaces and other user interfaces are more modern and similar to those commonly used by computer operators.

Reserve Component Automation System

Customer: Army Reserve Component

The Reserve Component Automation System (RCAS) is a \$2.3 billion automated information system that provides the Army National Guard (ARNG) and United States Army Reserve (USAR) with the capability to administer and manage day-to-day operations and mobilization planning. Added complexity comes from working with these two major customers. RCAS links more than 57,000 personal computers at 10,500 ARNG and USAR

units through a wide area network at over 4,000 sites in 54 locations: states, territories, and the District of Columbia. Each USAR unit reports to the governor and has both a state and federal support mission. It is noted that all users do not have the same needs or chains of command.

Beyond providing scalable system architecture, RCAS is an open system with two separate subsystems: classified and unclassified.

In March 2001, the project completed fielding of the system's infrastructure 18 months ahead of the original deployment schedule. In March 2003, delivery of all software functionality will be complete. Customer requirements span 11 functional areas and consist of over 70,000 function points of government off-the-shelf/commercial off-the-shelf and RCAS developed software.

SOF EISE IPT IDAS/MATT Upgrade

Customer: Special Operations Force Systems Program Office

The Interactive Defense Avionics System/Multi-Mission Advanced Tactical Terminal (IDAS/MATT) is a modification to the MH-53J Pave Low III (PL-III) aircraft and is now designated as PL-IV. The IDAS/MATT upgrade program incorporated the PL-IV aircraft system onto the

PL-III simulation network. This upgrade makes possible the software maintenance of the operational flight programs of the MH-53M weapon system. The MH-53M with IDAS/MATT is the world's most software intensive and technologically sophisticated helicopter. The continued high Mission Capability Rate (five percent over Major Command goal) of this Force Activity Designator 1 weapon system is only possible due to the support rendered by the Special Operations Forces Extendible Integration Support Environment with the IDAS/MATT upgrade.

The simulation network now supports both aircraft configurations with minimum hardware reconfiguration required. Hardware changes included updating the user interface function to reflect PL-IV cockpit changes and addition of an Embedded Computer Systems/Line Replaceable Unit (LRU) rack to host PL-IV unique LRUs. Software changes included the modification of 10 existing LRU simulations. In addition the flight, visual scene driver, and terrain/target simulations were modified.

Software block cycle change cycle time has dramatically dropped with the EISE upgrade. During a recent deployment, an emergency change request was analyzed and a fix developed, coded and tested in about two weeks. ♦

Top 5 Software Projects Scoring Criteria

Reviewers from the Software Technology Support Center (STSC), Hill Air Force Base, Ogden, Utah, used the following criteria and point system to score all nominations in order to select the 2001 Top 5 U. S. Government Quality Software Projects. Each nomination was awarded points (up to a maximum value) based on how well the project performed within each category: customer value, performance, technical value, and reviewer's discretion. Each nomination was scored by at least three STSC consultants or engineers with the top one-third of nominations being scrutinized more closely by the internal board in order to select finalists.

Customer Value – Maximum 40 Points

Problem Reports

- Were responses to the problem reports and questions timely?

Value

- What was the measured value to the customer's mission (return on investment)?

Benefits and Satisfaction

- Is the end product useable?
- Is the customer satisfied with the end result?
- What other benefits were provided to the customer?
- Was the developer collaborative?
- Did the developer listen to the customer?
- Was the developer knowledgeable? Informative? Helpful?
- Was the developer professional in letting the customer know requirements tradeoffs?

Performance – Maximum 25 Points

- Did the developer meet the contracted schedule?
- Did the developer meet the contracted budget?
- How many problem reports have been written against the product since system test?
- Is the customer satisfied with the end result?

Technical Value – Maximum 20 Points

- Was the problem challenging? How hard was this project to implement?
- Was the solution innovative? What approach was used to solve the problem? What technical value did they provide to the world?
- Is the project reusable? Can someone else use the end product, portions of the end product, code, process, or the product's technology to solve a future government problem?
- Is the project repeatable? Given a similar problem, could this group repeat this success or were they just lucky this time? (Did they use defined processes, trained people, etc.)

Reviewer's Discretion – Maximum 15 Points

Use or don't use these points as discretion dictates. Suggested considerations include the following:

- Previous awards (CMM, ISO 9000, Malcolm Baldrige, etc.).
- Customer. (Will one small organization use this or will it be dispersed worldwide?)
- Do they have measures that can be used for oversight and additional improvements?
- What is the atmosphere/morale of the developing organization?